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FINAL TECHNICAL REPORT

NASA GRANT NAGW-1092
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(NASA-CR-184769) [MIT-KSC SPACE LIFE
SCIENCES TELESCIENCE TESTBED] Final
Technical Report (Massachusetts Inst. of
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February, 1989

MIT-KSC Space Life Sciences Telescience Testbed

Experiment Description and Summary

As an element in the Telescience Testbed Pilot Program, the Massachusetts Institute of Technology Man-Vehicle Laboratory (MIT/MVL), Payload Systems Inc (Payload Systems), and the Kennedy Space Center(KSC) Life Sciences Flight Experiments Program worked to jointly develop a Telescience Life Sciences Testbed, in collaboration with MIT's School of Engineering and the advanced academic computing Project Athena.

The funding from NAGW-1092 supported the first phase of this effort, which consisted of defining the experiments to be performed, investigating the various possible means of communication between KSC and MIT, and developing software and hardware support. The science experiments chosen were two Vestibular Sled experiments, which would be performed at KSC by teams of trained Experiment Payload Specialists (EPSes). The experiments would be remotely monitored and controlled by a Principal Investigator (PI) and one assistant (API) at MIT, while telescience personnel at KSC and MIT varied the telescience experimental conditions. The two experiments were:

- 1) a study of ocular torsion produced by Y axis linear acceleration, based on the Spacelab D-1 072 Vestibular experiment performed pre- and post-flight at KSC.
- 2) an optokinetic nystagmus (OKN) /linear acceleration interaction Experiment, based on that proposed and recently selected for development for a future Spacelab mission (NASA '84 AO).

These two experiments were meant to simulate actual experiments that might be performed on the Space Station and to be representative of space life sciences experiments in general in their use of crew time and communications resources.

After considerable investigation of alternate systems, an Athena Advanced Visual Workstation was chosen as the video display medium. The PI used this workstation to view a realtime video picture of the Sled experiment and the data associated with sensors on the subject and on the Sled. In addition, several two-way voice links would be established between KSC and MIT using ordinary telephone lines. Communication would be possible between the telescience personnel at either end and between the PIs and the EPSs.

Communication would be possible between the telescience personnel at either end and between the PIs and the EPSSs. Various internal communication links were also set up at KSC and MIT to allow other types of communication (CIC).

During the experiment operations, the PI would evaluate his/her ability to monitor and control the experiment and perform a remote coaching function when the surveillance video bit rate was limited, and data links and voice protocols were degraded. The experiment design was to evaluate schemes for video bit rate reduction using operator selected changes in frame rate, resolution, grey scale and color parameters. The PI would also evaluate the type of information displays needed to properly interact with the remote experiment, archive data for near real time analysis, and to maintain written, voice, and video logs.

The goals of the MIT/KSC testbed project were to:

- Evaluate the methodology for conducting an actual life sciences experiment over real physical distance with voice, video, and data interaction between the experiment and the remotely located investigators.
- Identify Space Station Information System's (SSIS) Science and Applications Information System (SAIS) requirements for experiments requiring real time voice, video, and data interaction between investigators, station crewmembers, and space station operations personnel.
- Develop telescience methodologies whereby students at universities can become directly involved in space station science activities.

This research is focused on the role of the PI in performing a "remote coaching function", and will investigate the following issues:

- allocation and use of reduced surveillance video bandwidth
- voice protocols for investigator/crewmember interaction
- investigator workstation design for use with integrated video, text, and graphics.

The testbed project is designed as "an experiment within an experiment". The Telescience Experiment is the primary experiment but the simulated experimental payload, in this

experiment but the simulated experimental payload, in this case the U.S. Laboratory Sled at the KSC Baseline Data Collection Facility (BDCF), is the science experiment within the Telescience Experiment.

The project was carried out under the "rapid prototyping" philosophy adopted for the USRA/RIACS university based telescience projects: A high fidelity simulation of the Space Station Information System (SSIS) was not attempted; only those aspects believed germane to the hypotheses under examination were simulated, taking technical shortcuts where necessary. No attempt was made to produce hardware or software which could be directly adapted for the SSIS. Rather, the role of the TTPP testbeds was to define via simulation the key technical systems, parameters, procedures and concepts which must be considered in the design of the SSIS in order to maximize the science utility of the space station.

The following hypotheses were to be investigated:

- o Surveillance of Space Station experiment operations using real time data and video by the PI team, and real time voice communications between the PI and crew result in increased science productivity because mistakes can be caught, and serendipitous events can be exploited quickly. [This assumption, inherent in the "telescience" concept, we often take for granted. Is it true?]
- o Surveillance of the experiment set-up phase is as important as monitoring of actual experiment execution.
- o Latency of downlinked data reaching the PI station is a critical SSIS network design parameter. Current SSIS network design concepts speak only in terms of "grades of service", but put no absolute specification on latency. If latency between the space station and the PI exceeds several seconds, correspondence between real time video, voice and data displays may be lost, making the PI's monitoring function much more difficult, and making it harder to spot problems in real time.
- o Technology issues aside, operation of the PI workstation by two people rather than one is the preferred mode.
- o PIs can probably "get along" with relatively low video bit rates (300K-500 Kbits/sec or less) for surveillance purposes. Interactive Life Sciences experiments use realtime video extensively for surveillance of crew activities, and (in the case of our Sled experiment) for science data. Bandwidth restrictions on downlinked video will force

compression of surveillance and Sled experiment data video. PIs are concerned that compression schemes may significantly degrade their surveillance function. We would like to demonstrate that using appropriate observer controlled Frame Rate, Resolution, and Grey scale/color

- o PIs can perform their surveillance function at lower video bit rates than then they subjectively "like", particularly if they can control compression parameters, and if "snapshots" of high resolution video can be made available on demand.

- o Having more than one surveillance video camera, and the ability to control these cameras from the ground under direction from the PI increases science productivity.

- o It is possible for a human observer to judge the technical adequacy of ocular torsion video science data, and even visually estimate the magnitude of ocular torsion (via comparison of freeze frame displays) using less than full bandwidth video.

- o The rules and constraints which govern voice communications between the PI and the crew can have a major impact on the science productivity of the entire team. Negative impacts result when:

PIs can only pass messages to the crew indirectly through the CIC, rather than speaking directly to them.

Direct crew-PI voice communication much be enables via a POCC permission granting process each time the PI wishes to speak with the crewmember(s) performing his experiment.

Protocol requires crewmember to stop, key mike, and acknowledge all transmissions, rather than using normal conversational mode.

PIs inadvertently interfere with crew concentration and experiment progress by overusing the voice channel.

- o Effectiveness of "Quick look" evaluation of data by PIs can be considerably enhanced if state of the art computer graphics technology is used to create an "all glass" PI workstation, with integrated engineering, data, and video windows with full "scrolling lookback" capability for video, voice, and data.

o Science productivity is impaired when crew and PIs must race against the MET clock when conducting an experiment, rather than working in the more open-ended mode typical of ground laboratories.

The physical configuration of the MIT and KSC facilities is shown in the following figures.

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MIT/KSC TELESCEIENCE TESTBED
TELESCEIENCE OPERATIONS
PRELIMINARY VIDEO CONFIGURATION

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VIDEO CONFIG
TELESCEIENCE

KENNEDY SPACE CENTER

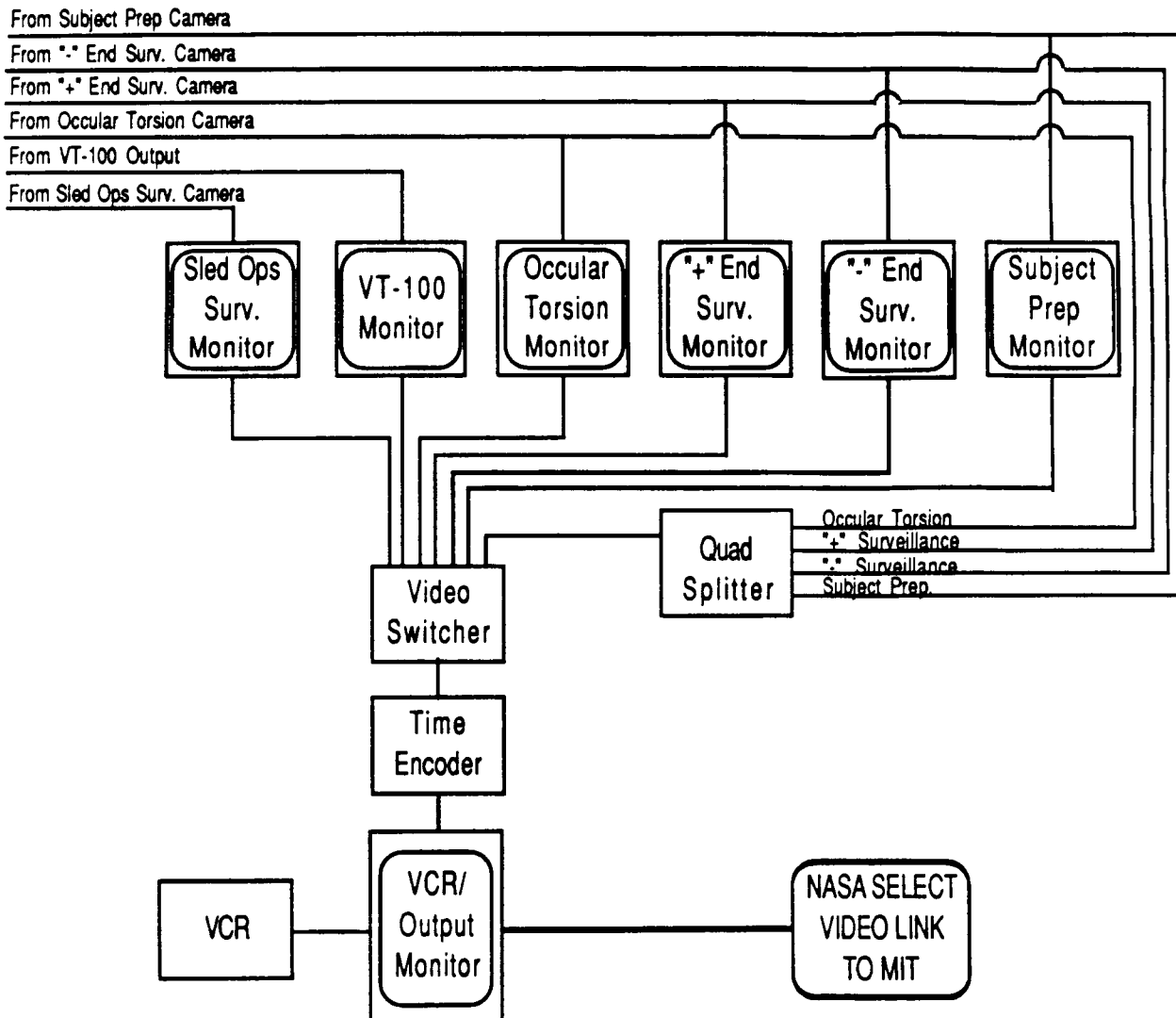


FIGURE 2.2-1 KSC Video Configuration

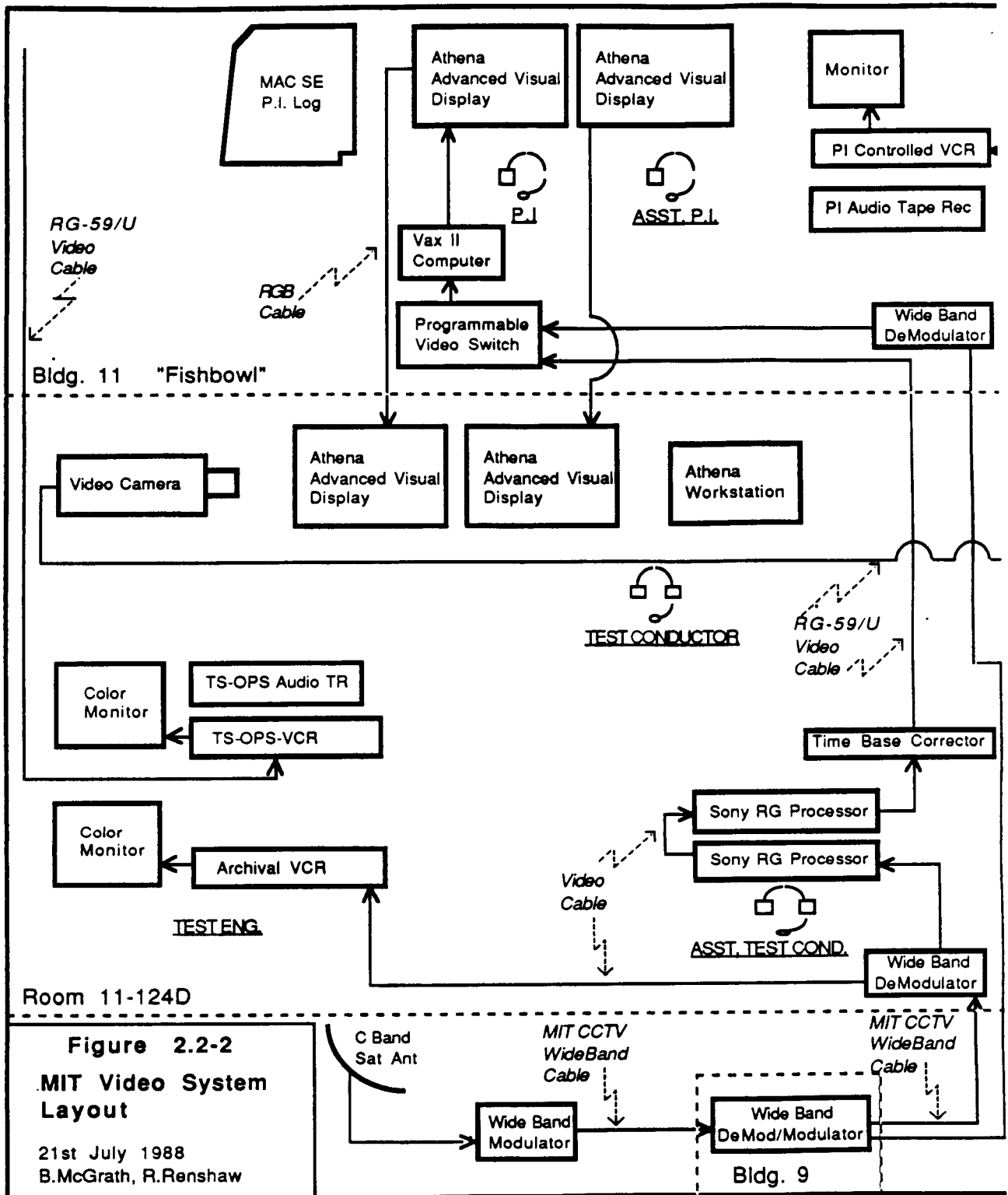


Figure 2.2-2
MIT Video System
Layout

21st July 1988
B. McGrath, R. Renshaw

MIT/KSC TELESCIENCE TESTBED AUDIO SYSTEM CONFIGURATION

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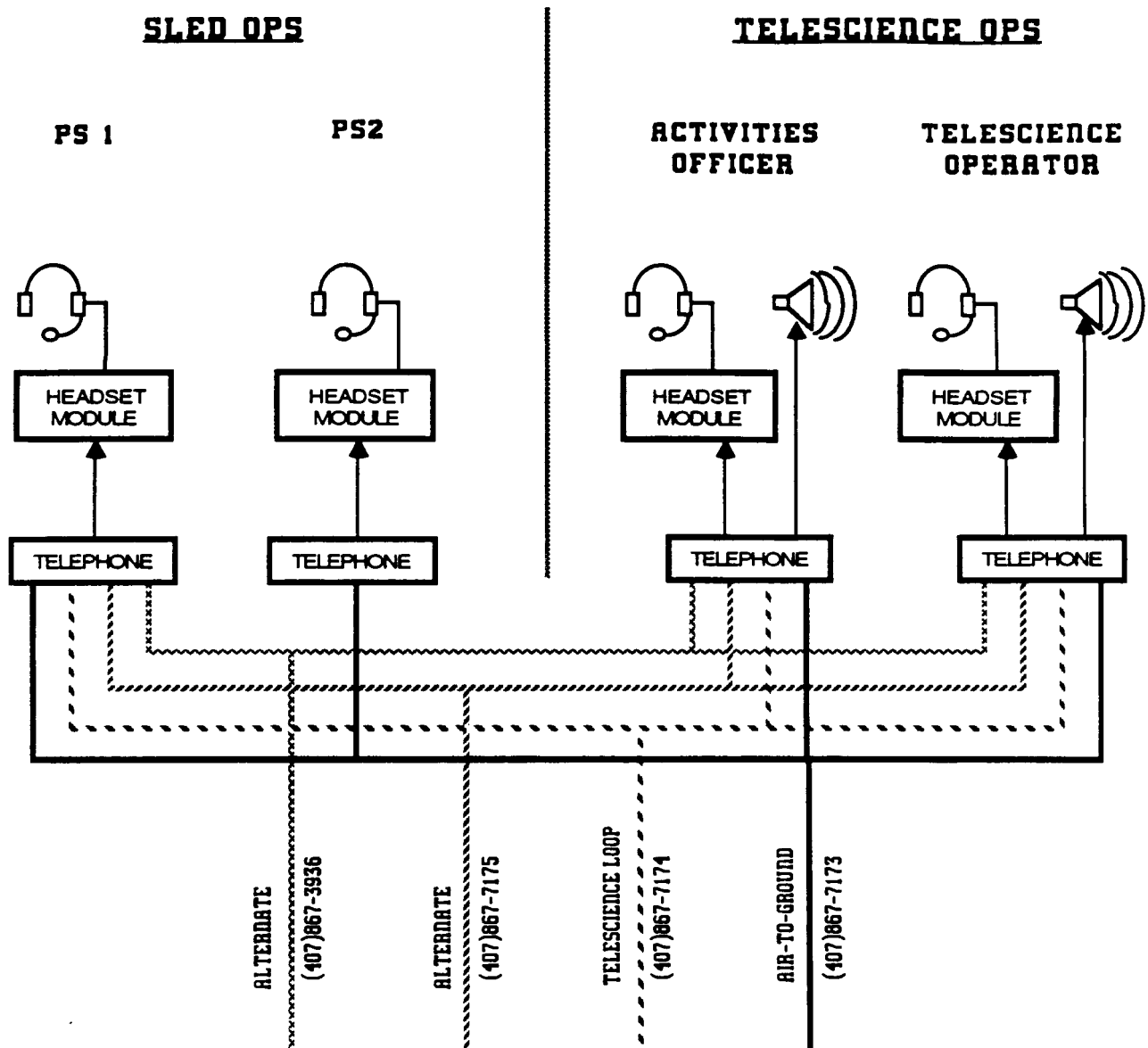


Figure 2.2-3 KSC Voice Communications

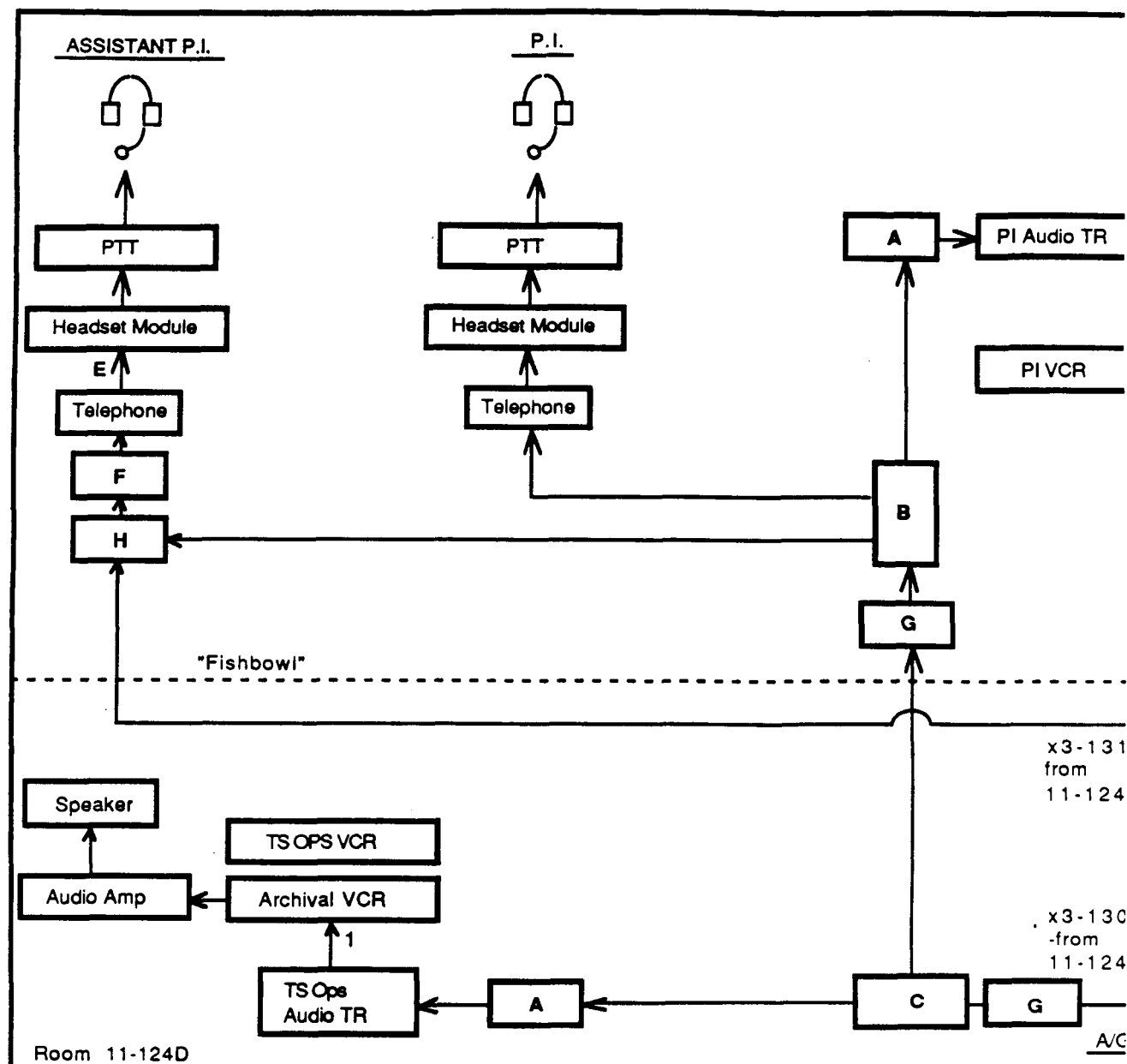
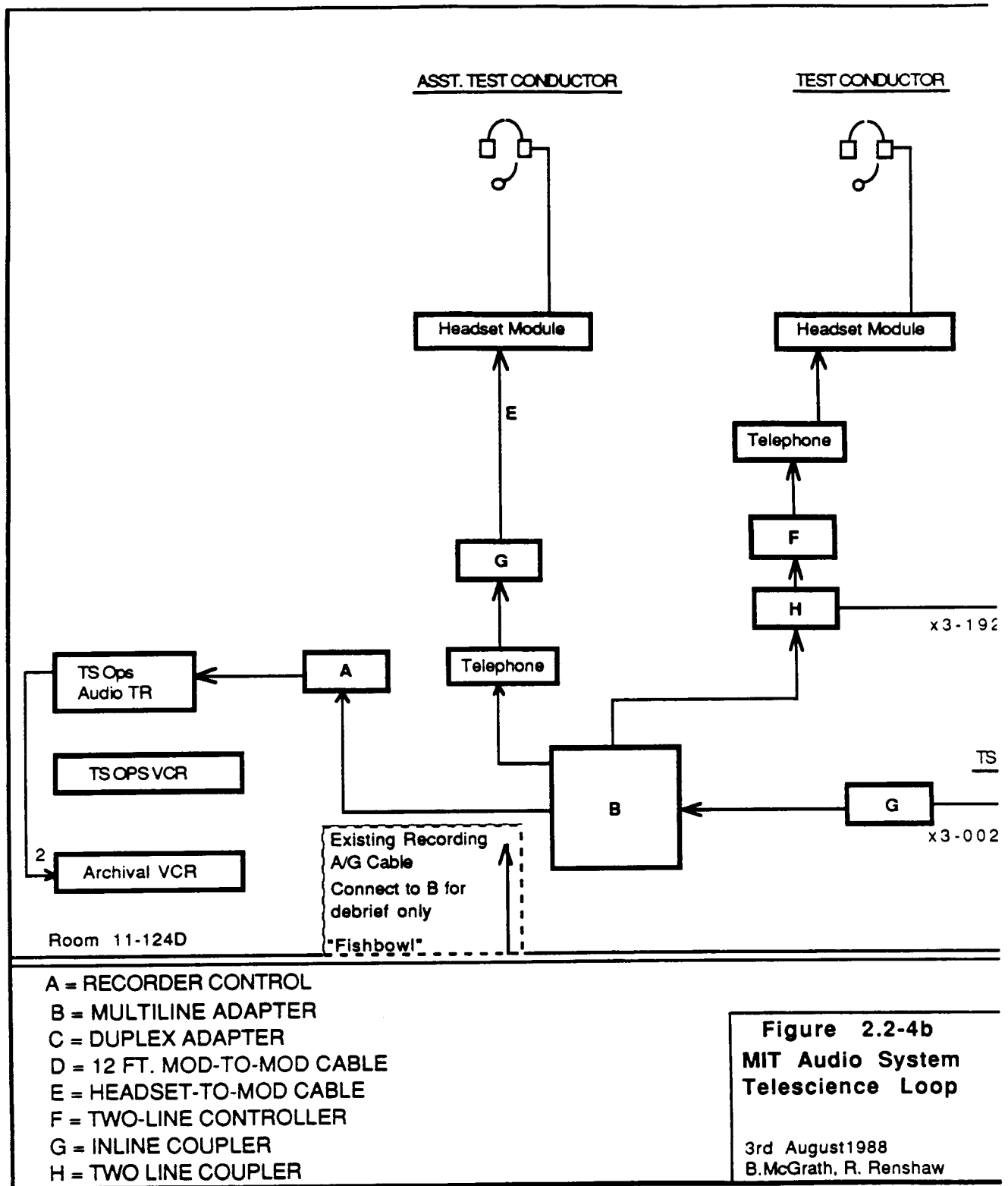


Figure 2.2-4a
MIT Audio System
Air-to Ground Loop
4th August 1988
B.McGrath, R.Renshaw



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MIT/KSC TELESCIENCE TESTBED

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EXPERIMENT OPERATIONS

EXPERIMENT OPS
TELESCIENCE

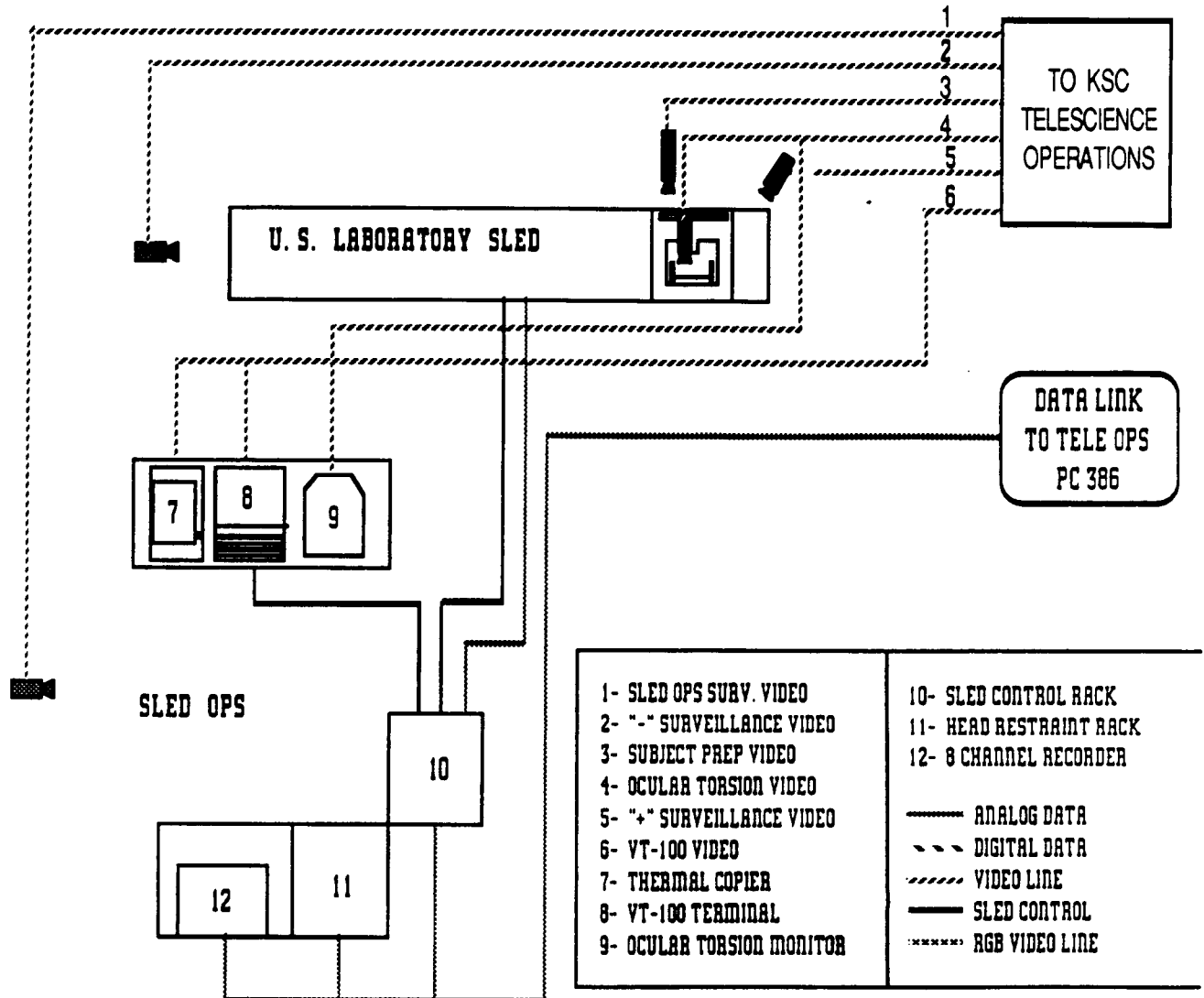
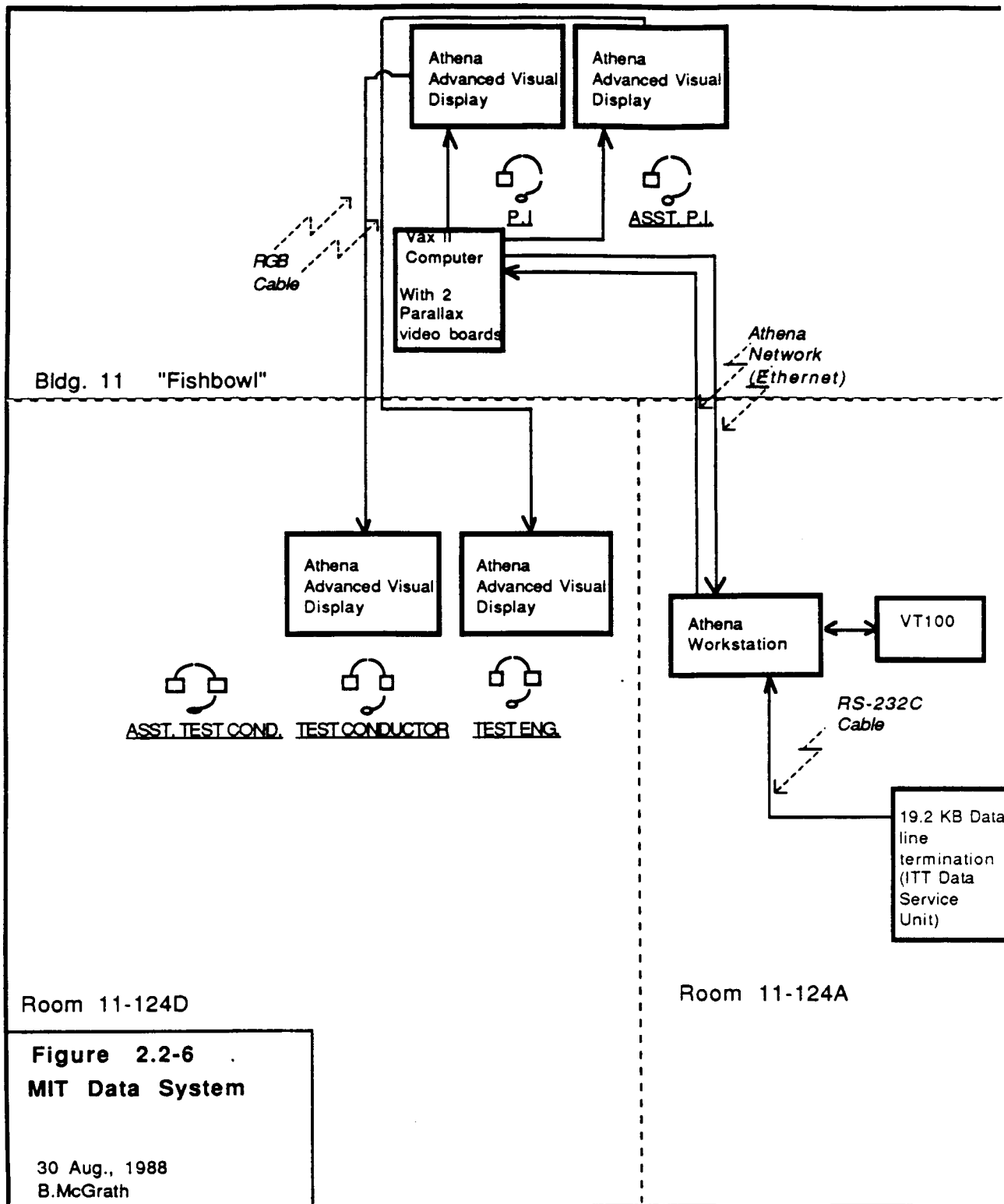


Figure 2.2-5 KSC Experiment Operations

October 13, 1988



The schedule for the life sciences telescience program is shown in the following figure.

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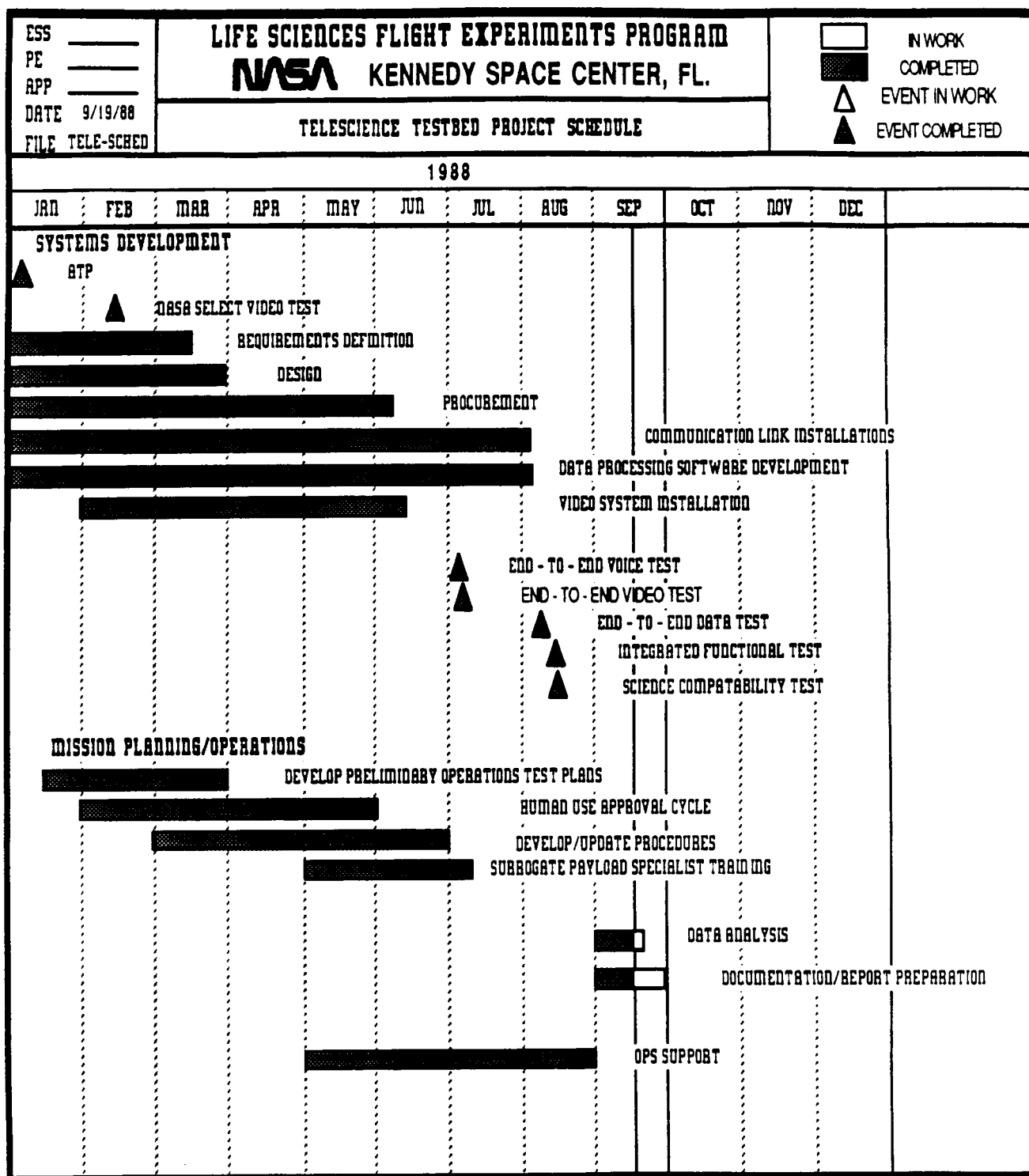


Figure 3.2-1 Overall Telescience Schedule

For results of this project, please see the Final Report of the next phase of the project, contained in: Telescience Testbed Pilot Program, Final Report, Volume III. Experiment Summaries. RIACS Technical Report, 1989.

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MIT/KSC LIFE SCIENCES TESTBED - EXPERIMENT PAYLOAD
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